

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
29 July 2004 (29.07.2004)

PCT

(10) International Publication Number
WO 2004/064448 A1

(51) International Patent Classification⁷: **H04R 9/06**

(21) International Application Number:
PCT/IB2003/006222

(22) International Filing Date: 8 December 2003 (08.12.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
03100057.3 14 January 2003 (14.01.2003) EP

(71) Applicant (for all designated States except US): **KONINKLIJKE PHILIPS ELECTRONICS N.V. [NL/NL]**;
Groenewoudseweg 1, NL-5621 BA Eindhoven (NL).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **ERMENS, Annick, S., I. [BE/BE]**; c/o Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL).

(74) Agent: **SCHRIJNEMAEEKERS, Hubert, J., M.**; Philips Intellectual Property & Standards, Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL).

(81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR,

CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

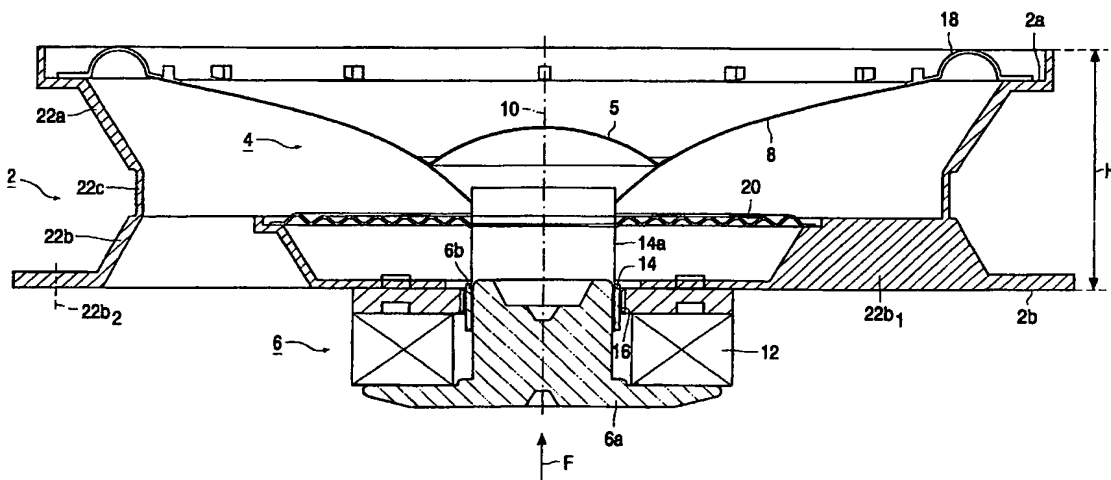
(84) Designated States (regional): ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declaration under Rule 4.17:

— as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii)) for the following designations AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW, ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, SD,

[Continued on next page]

(54) Title: **LOUDSPEAKER**



(57) Abstract: The invention relates to a loudspeaker, particularly intended for use in a motor vehicle. The loudspeaker includes a housing (2) with a front side (2a) and a rear side (2b), a diaphragm (8) flexibly connected to the housing and an actuator (6) for displacing the diaphragm with respect to the housing along a translation axis (10). This axis imaginarily extends from said one side to said other side of the housing. The housing extends around the translation axis and includes a conical forepart (22a) widening towards the forepart, a base part (22b) positioned at the rear side and an intermediate housing part (22c). The intermediate part extends between the forepart and the base part and includes transition areas (22c1, 22c2) connected to these parts. The transitions behave as hinges under the influence of an axial load above a certain value, whereby the intermediate housing portion turns towards the translation axis and the forepart turns towards the rear side under the influence of such a load.

BEST AVAILABLE COPY



SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)

Published:

— with international search report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Loudspeaker

The invention relates to a loudspeaker, particularly intended for use in a motor vehicle, which loudspeaker includes a housing with a front side and a rear side, a diaphragm accommodated in the housing and flexibly connected to the housing, and an actuator for displacing the diaphragm with respect to the housing along a translation axis imaginarily
5 extending from said one side to said other side of the housing, the housing extending around the translation axis.

Patent specification EP 0 510 345 B1 discloses a loudspeaker for use in motor vehicles. The known loudspeaker comprises a conical housing, a conical frame movably supported by the housing and an electromagnetic actuator. The conical frame, at one end of
10 which the magnet system is permanently arranged, has a predetermined breaking point which is dimensioned in such a way that it should rupture beyond a predetermined force acting on the magnet system, and the part of the frame to which the magnet system is attached should decouple from the other part of the frame. In an alternative embodiment, the conical frame of the known loudspeaker has a continuous predetermined rupture zone which, in the event of a
15 force acting on the magnet system, should ensure that the frame telescopes concertina-fashion in the determined rupture zone.

As is generally known, safety aspects are becoming more and more important for vehicles. In this context, it can be stated that all components in a car, and thus also built-in loudspeakers, may injure the driver and passengers, if any, in the event of a crash or
20 collision. As the number of loudspeakers mounted in a car is still ever-increasing and more and more loudspeakers in cars are positioned in the direct vicinity of the occupants, loudspeakers play an essential role in meeting current safety requirements imposed on vehicles. It has appeared that rupture points and zones applied in the conical frame of the known loudspeaker are not very reliable when it comes to meeting the above-mentioned
25 safety requirements.

It is an object of the invention to improve the loudspeaker of the kind as defined in the preamble in such a way that it conforms to the current safety requirements imposed on speakers mounted in a motor vehicle.

According to the invention, this object is achieved with the loudspeaker which includes a housing with a front side and a rear side, a diaphragm accommodated in and flexibly connected to the housing and an actuator for displacing the diaphragm with respect to the housing along a translation axis imaginarily extending from said one side to said other
5 side of the housing, wherein the housing extends around the translation axis and is provided with a conical forepart widening towards the front side, a base part extending towards the rear side and an intermediate housing part extending between the forepart and the base part and including transition areas connected to the forepart and the base part, which transition areas behave as hinges under the influence of an axial load above a certain value, whereby
10 the intermediate housing portion turns towards the translation axis and the forepart turns towards the rear side under the influence of such a load. If an axial force of a certain minimum value is exerted at the front side and/or the rear side of the housing, the transition areas of the intermediate housing part deform in such a way that the intermediate housing part turns inwardly, resulting in a shortening of the housing and thus of the loudspeaker as
15 such. If desired, the transition areas can be designed in such a way that they break after a certain bending. The mentioned axial force or load may of course also be a component of a force or load, respectively, exerted under an angle, with regard to said sides.

The actuator applied in the loudspeaker according to the invention is usually an electromagnetic actuator which is known per se. Such an actuator has a magnet system
20 attached to the housing, particularly the base part thereof, and a so-called voice coil fixed to the diaphragm. In such a device, the housing and the magnet system are generally the most dangerous components of loudspeakers built into a vehicle, in the case of an accident.

The loudspeaker according to the invention is able to conform to contradictory requirements, viz. the requirement that it is not allowed that the magnet system comes loose
25 from the housing and the requirement that, if during a crash or collision the loudspeaker is pressed against a human body, it is not allowed that a predetermined maximal force exerted on the human body is exceeded. It has appeared that the housing of the loudspeaker according to the invention is solid enough to prevent a disconnection of the magnet system and is weak enough to absorb sufficient energy by plastic deformation, if necessary.

30 In a practical embodiment of the loudspeaker according to the invention, the intermediate housing has a substantially cylindrical shape. The transition areas may have another shape, and may be e.g. curved or S-shaped.

It is not necessary that the housing of the loudspeaker according to the invention is made of only one material. Usual materials for housing are e.g. polycarbonate

and ABS (acrylnitril-butadien-styrol copolymer). By making the transition areas of another material, specific properties, such as e.g. a springback function, can be given to these areas. The housing can be manufactured by e.g. injection molding. Apart from the above-mentioned materials, suitable materials for the intermediate part are e.g. thermoplastic polyester
5 elastomers and thermoplastic rubbers.

Alternatively, the transition areas can be formed from separate sheet materials such as rubber, rubber-plastic compounds, plastics and steel. For the above-mentioned reasons, the material of the intermediate housing part of a preferred embodiment is different from the material of the forepart and/or the base part.

10 Another practical embodiment has the feature that the transition areas are weaker than the other portions of the housing.

It has been proved that the following features are preferred. The forepart of the housing has an angle of inclination, related to a line parallel to the translation axis, which is at least 30 degrees. A suitable maximum value of the angle is 60 degrees. The intermediate
15 housing part has a length dimension, viewed along a line parallel to the translation axis, which is at least 3 mm. The intermediate housing part preferably has a thickness dimension, viewed in a direction perpendicular to the translation axis, which is minimally 0.5 mm. As a rule, the thickness of the intermediate part is about 50% of the thickness of the other mentioned parts of the housing.

20 The invention also relates to a housing for use in the loudspeaker according to the invention. The housing according to the invention is constructed and structured as described elsewhere in this document.

It is noted in relation to the set of claims that various combinations of characteristic features defined in the claims are possible.

25 The above-mentioned and other aspects of the invention are apparent from and will be elucidated, by way of non-limitative examples, with reference to the embodiments described hereinafter.

30 In the drawings:

Fig. 1 shows an embodiment of the loudspeaker according to the invention in a diagrammatic cross-section,

Fig. 2 shows, in a cross-section, an essential part of the housing of the embodiment shown in Figure 1,

Fig. 3 shows, in a cross-section, the above-mentioned essential part after a small deformation of the housing as shown in Figure 2,

Fig. 4 shows, in a cross-section, the essential part after a large deformation.

5

The electrodynamic loudspeaker according to the invention, shown in Figure 1, comprises a housing 2, a translatable body 4 and an electromagnetic actuator 6. The loudspeaker has a height H and is shielded by a dust cover 5. The housing 2, which is made of ABS in this example, has a front side 2a and a rear side 2b. The housing 2 may have a
10 more or less closed contour or may be in the form of a more open frame. The translatable body 4 comprises a three-dimensional diaphragm 8, which is situated or at least extends in the housing 2. The function of the electromagnetic actuator 6 is to displace the body 4, and thus the diaphragm 8, along a translation axis 10, being the central axis of the loudspeaker, extending from the front side 2a to the rear side 2b, or vice versa. The actuator 6 essentially
15 comprises two elements, namely a stationary actuator element 6a which is fixed to the housing 2, and a translatable actuator element 6b which is attached to the translatable body 4. The stationary element 6a is provided with a magnet system having an annular permanent magnet 12, and the other actuator element 6b is provided with a coil system having at least one magnet coil 14. When energizing the coil 14, both actuator elements 6a, 6b magnetically
20 co-operate with each other over an air gap 16 for generating a driving force on the translatable body 4 parallel to the translation axis 20 and hence on the diaphragm 8 forming part thereof. Said magnet system also has soft iron parts which, together with the permanent magnet 12, form a magnetic yoke defining the air gap 16. The magnet coil 14, being a cylindrical coil, also referred to as voice coil, is situated on a coil support 14a which is
25 formed as a cylinder body being part of the translatable body 4.

The loudspeaker is provided with a flexible connection for the translatable body 4 and hence for the diaphragm 8. This flexible connection comprises a first flexible connecting means 18 proximate to the front side 2a of the housing 2 and a second flexible connecting means 20 proximate to the rear side 2b of the housing 2. The flexible connection
30 is to ensure that the body 4, and particularly the diaphragm 8, can perform well-defined translation movements with respect to the housing 2. The first flexible connection means 18 has a flexible structure formed from, for example, a corrugated rubber annular rim which is secured, for example, glued on its outer circumference to the housing 2 and on its inner circumference to the translatable body 4. The second flexible connection means 20 is formed

as an undulating spider of, for example, textile or fabric, wherein the spider is attached to the housing 2 and to the translatable body 4.

In the further description, reference is also made to Figures 2 to 4.

In the loudspeaker according to the invention, the housing 2 is provided with a
5 conical forepart 22a, a base part 22b and a cylindrical intermediate part 22c. The conical part 22a is positioned near the front side 2a of the housing 2 and widens toward the front side 2a. The base part 22b is located near the rear side 2b of the housing 2, may be widening towards the rear side 2b and may be strengthened by a rib structure 22b₁. The base part 22b may be provided with mounting means 22b₂ for mounting the loudspeaker into a case, e.g. formed by
10 a door of a motor vehicle. The intermediate part 22c extends between the forepart 22a and the base part 22b and has transition areas 22c₁ and 22c₂ by means of which it is connected to the part 22a and the part 22b, respectively. These transition areas 22c₁ and 22c₂ are dimensioned in such a way that they function as hinges beyond a predetermined axial load (L) acting on the housing 2 and directed in a direction from the one side (2a or 2b) of the housing 2 to the
15 other side (2b or 2a) of the housing 2. Such a load may be caused by a forward axial force F acting on the magnet system 6a of the actuator 6, while the front side 2a of the housing 2 is prevented from moving in the forward axial direction. During hinging, i.e. bending, the transitions 22c₁ and 22c₂, the forepart 22a and the base part 22b relatively turn to each other, in addition to which the forepart 22a simultaneously moves inwardly, i.e. towards the
20 translation axis 10. These complex movements are demonstrated in Figures 3 and 4. As can be derived from Figure 3, which shows the core in which only a relatively small deformation of the housing has taken place, the transition 22c₁ hinges outwardly while the transition 22c₂ hinges inwardly. In the situation shown in Figure 4, further deformation of the transitions 22c₁ and 22c₂ has taken place, resulting in a considerable reduction of the original height H
25 of the loudspeaker without the risk of causing sharp edges.

The design can be optimized and/or tuned by adapting the value w, i.e. the angle of inclination extending between the forepart 2a of the housing 2 and a line parallel to the translation axis 10, the value T, i.e. the thickness of the cylindrical intermediate part 2c, and the value L, i.e. the length of the intermediate part 2c, to the desired elastic deformation
30 of the housing in relation to a certain load. In this context, it is noted that a certain length L is required in order to create two hinges.

It has been proved that the larger the length L, the easier the forepart of the housing can move inwardly. It has further been proved that the larger the angle w, the smaller the nominal force which is needed for bending the transitions. In other words, the housing of

the loudspeaker according to the invention can easily be designed to meet the requirements of the customers. The design is very suitable for simulations, by means of which the desired values of the above-mentioned parameters can be easily determined. The desires of the clients may be various; e.g. a customer might require a deformation of 50% under the influence of an axial force of 3000N, and another customer might require a deformation of 30% in the case of a force of 2500N at an angle of 45° with regard to the translation axis.

If desired by a client, the design can be determined in such a way that the deformations of the transitions may result in a break of a transition.

If suitable, the material of the intermediate part 2c can be chosen to be different from the material of the other parts 2a and 2b.

CLAIMS:

1. A loudspeaker including a housing (2) with a front side (2a) and a rear side (2b), a diaphragm (8) accommodated in and flexibly connected to the housing and an actuator (6) for displacing the diaphragm with respect to the housing along a translation axis (10) imaginarily extending from said one side to said other side of the housing, wherein the housing extends around the translation axis and is provided with a conical forepart (22a) widening towards the front side, a base part (22b) extending towards the rear side and an intermediate housing part (22c) extending between the forepart and the base part and including transition areas (22c₁, 22c₂) connected to the forepart and the base part, which transition areas behave as hinges under the influence of an axial load above a certain value, whereby the intermediate housing portion turns towards the translation axis and the forepart turns towards the rear side under the influence of such a load.
2. A loudspeaker as claimed in claim 1, wherein the intermediate housing part has a substantially cylindrical shape.
3. A loudspeaker as claimed in claim 1, wherein the material of the intermediate housing part is different from the material of the forepart and/or the base part.
4. A loudspeaker as claimed in claim 1, wherein the transition areas are weaker than the other portions of the housing.
5. A loudspeaker as claimed in claim 1, wherein the forepart of the housing has an angle of inclination, related to a line parallel to the translation axis, which is at least 30 degrees.
6. A loudspeaker as claimed in claim 1, wherein the intermediate housing part has a length dimension, viewed along a line parallel to the translation axis, which is at least 3 mm.

7. A loudspeaker as claimed in claim 1, wherein the intermediate housing part has a thickness dimension, viewed in a direction perpendicular to the translation axis, which is minimally 0.5 mm.
- 5 8. A housing for use in the loudspeaker as claimed in any one of the preceding claims, the housing being constructed as defined in any one of the preceding claims.

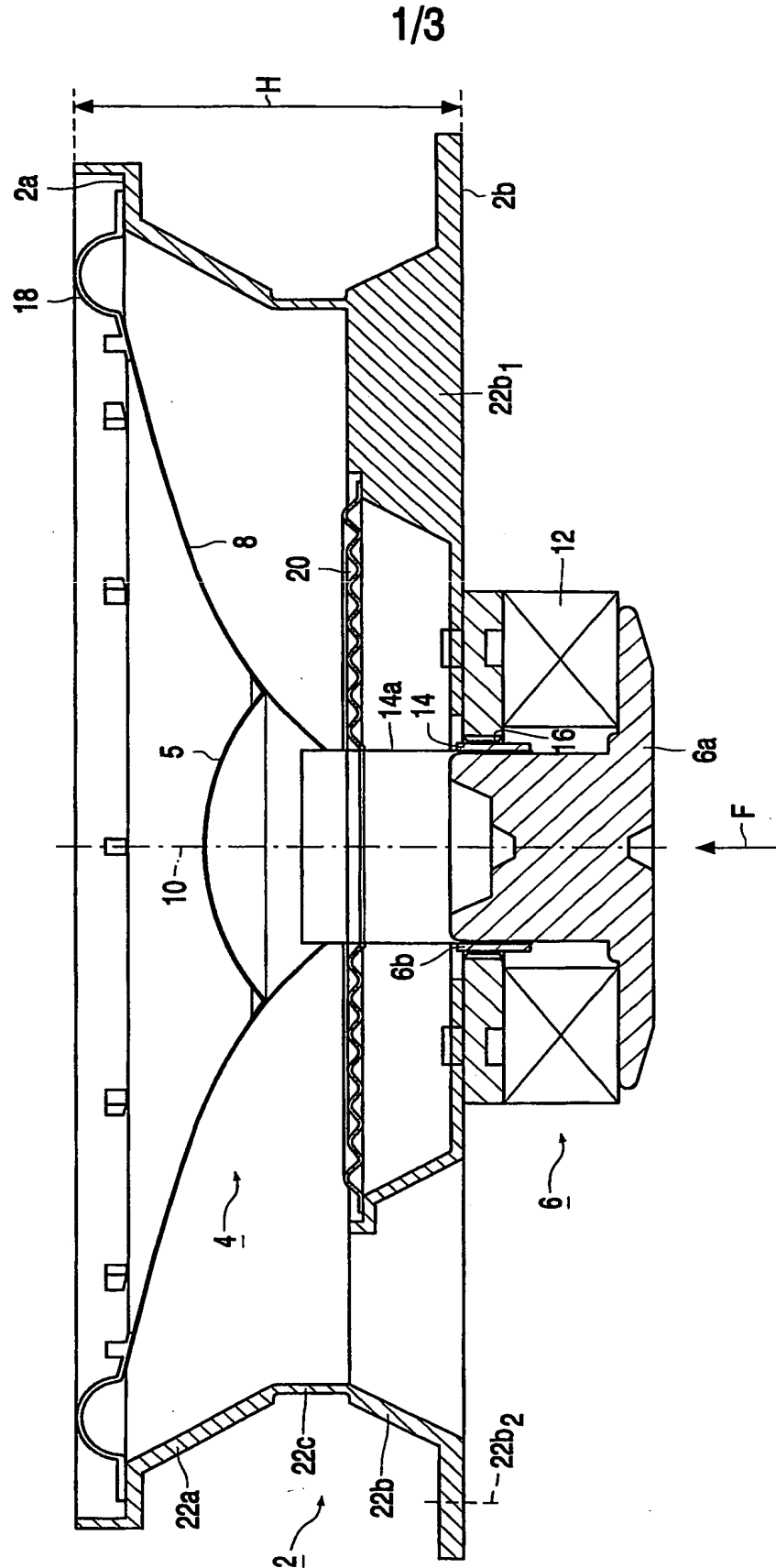


FIG. 1

2/3

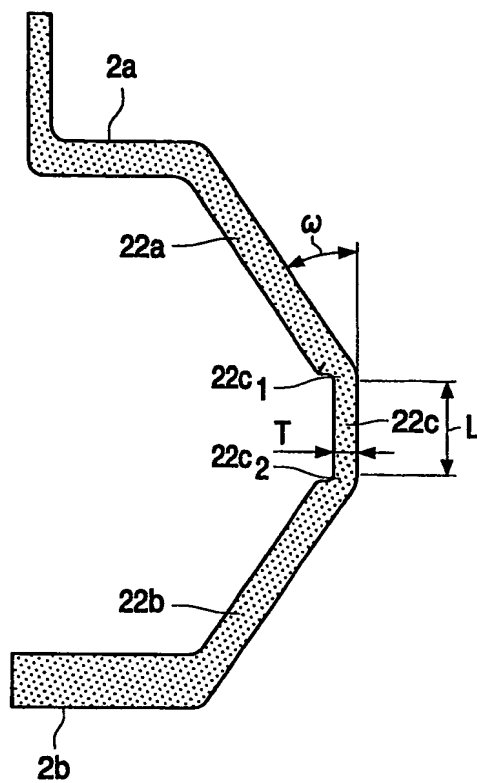


FIG. 2

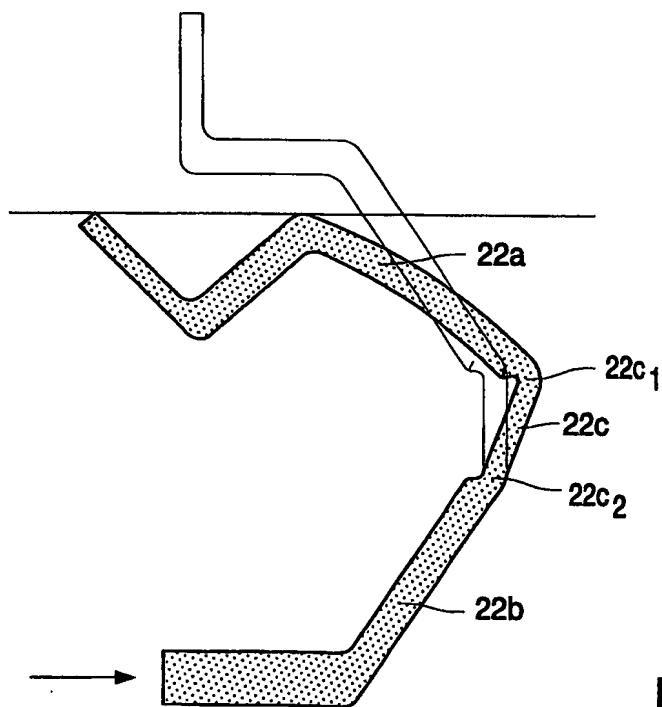


FIG. 3

3/3

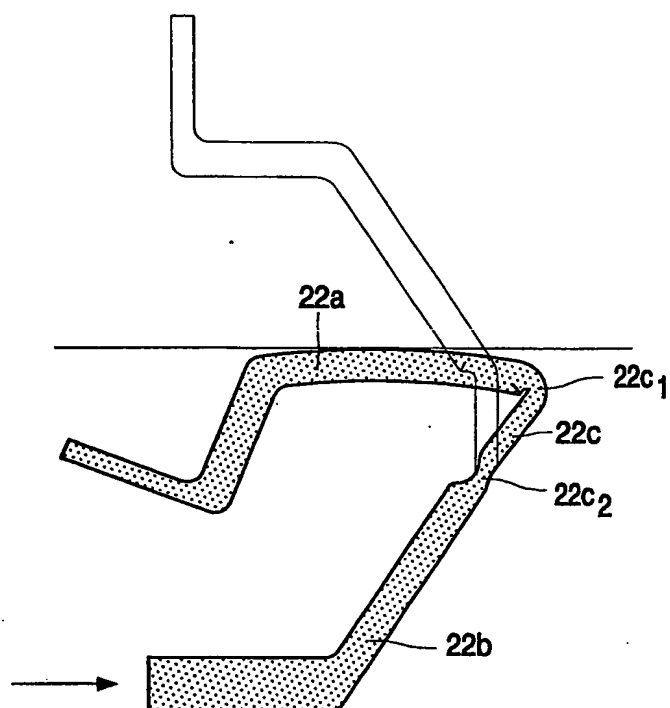


FIG. 4

INTERNATIONAL SEARCH REPORT

Inte Application No
PCT/IB 03/06222

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04R9/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 510 345 A (NOKIA DEUTSCHLAND GMBH) 28 October 1992 (1992-10-28) the whole document	1-8
A	DE 44 34 719 A (PIONEER ELECTRONIC CORP ;PIONEER ELECTRONIC TOHOKU (JP)) 6 April 1995 (1995-04-06) column 2, line 40 -column 3, line 22; figure 4B	1-8
A	US 2002/044671 A1 (SHIMOMURA KATSUYA ET AL) 18 April 2002 (2002-04-18)	

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

23 April 2004

Date of mailing of the international search report

10/05/2004

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Fülöp, I

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB 03/06222

Patent document cited in search report		Publication date		Patent family member(s)	Publication date
EP 0510345	A	28-10-1992	DE	4113017 A1	22-10-1992
			CS	9201200 A3	18-11-1992
			DE	59207151 D1	24-10-1996
			EP	0510345 A2	28-10-1992
			HU	60881 A2	28-10-1992
			JP	5252590 A	28-09-1993
			PL	294165 A1	08-02-1993
DE 4434719	A	06-04-1995	JP	7107582 A	21-04-1995
			DE	4434719 A1	06-04-1995
US 2002044671	A1	18-04-2002	JP	2002010392 A	11-01-2002

THIS PAGE BLANK (USPTO)

**This Page is Inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record**

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ **BLACK BORDERS**
- ☐ **IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- ☐ **FADED TEXT OR DRAWING**
- ☐ **BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- ☐ **SKEWED/SLANTED IMAGES**
- ☐ **COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- ☐ **GRAY SCALE DOCUMENTS**
- ☒ **LINES OR MARKS ON ORIGINAL DOCUMENT**
- ☐ **REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- ☐ **OTHER:** _____

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.

THIS PAGE BLANK (USPTO)